representing respectively the order and rate of removal of silicon, phosphorus, and carbon from pig iron in the author's purifying process, in the Bessemer converter, with both acid and basic linings, during the process of mechanical puddling, in the refinery, and during the process of puddling by hand labour.

The thirty-four pages of Section XV. of the volume are devoted to the consideration of facts and figures better calculated to interest the trader and economist, than the manufacturer or scientist; it contains extracts from the statistical returns of the condition of the trade, and make of iron in Great Britain, Germany, France, Belgium, and the United States. Then there follow two sections full of interesting and valuable information upon the labour question, and the effects of free trade principles upon the iron industries. In these sections comparisons are made of the relative cost and efficiency of the British workman as compared with his continental competitor and his American cousin. Commencing with the agricultural labourer, the coal and ironstone miner, the labour employed at the blast furnace, the puddling furnace, in the Bessemer and other methods of steel production, and finally in the engineering and shipbuilding industries, the author shows that throughout, although wages are considerably higher in Great Britain than in any Continental iron-producing district, yet that the English workman, being better fed, does more work per day than his competitor; or, in other words, fewer hands are required in Great Britain than are necessary for the performance of the same work where foreigners are employed. The comparison with the labour of the United States stands, however, differently, the American workman, as a rule (not without exception), receiving a higher rate of wages than the corresponding class in England; such examples being conspicuous amongst the various classes of mechanics, while the individual labourer at the blast furnace is paid at about the same rate in the two countries; but from various causes Mr. Bell states that "the labour on a ton of metal in America amounts to nearly double, and often more than double, its cost in England," and similar results apply to the production of malleable iron by hand-puddling, or to steel ingots from the Bessemer converter.

The last chapter of the volume compares with one another the chief iron-producing countries of the world, their national resources, their competition with Great Britain in English and foreign markets, and the effects of improvements, more especially of the basic process, upon the German steel industries. Mr. Bell concludes the volume with a brief discourse upon the present prospects of the iron trade of the world, and draws the conclusion that the cost of production of pig iron and of steel cannot be materially reduced, except by the reduction of royalties, railway charges, and wages; whilst the puddling furnace is doomed to extinction by its more powerful rivals the Bessemer converter and the open-hearth steel-melting furnace; so that there is little inducement for ironmasters to incur any expense in experiments aiming at the improvement of mechanical puddling appliances. The last-mentioned conclusion is pretty generally accepted, but that the cost of producing pig iron and steel cannot be materially reduced may well be questioned when the immense developments of the last twenty years are considered; and there are many who still hope to see some continuance of this progress, possibly in the direction of a still more economical production of steel from phosphoric and other inferior ores, either by direct processes or by improvements in the existing types of procedure.

The statistical portion of the work is often very indefinite as to the date to which the figures apply to different localities, and the six sections comprised between pp. 61 and 342, treating as they do of the reactions in the blast furnace, the use and theory of the hot-blast, the quantity and quality of fuel required in the blast furnace using air at different temperatures, of the solid products and of the chemical changes as they take place in the blast furnace, on the equivalents of heat evolved by the fuel in the blast furnace, on hydrogen and certain hydrogen compounds in the blast furnace. Each of these sections contains, as might be expected, much valuable information upon the theoretical considerations affecting the combustion of fuel, the effects of increasing the height and capacity of the furnace, and the limits to which the temperature of the blast may be raised with economical results; but the sections might be advantageously condensed, and much repetition avoided, by a more systematic arrangement of the facts and data.

The chemical analyses, results of experiments, the various facts and data, statistical and otherwise, with the discussions thereon as contained in Mr. Bell's volume, make it a most important and invaluable contribution to the literature bearing upon the scientific and economic considerations of our great iron industry, and this notwithstanding that the theoretical deductions which the author propounds may fail to secure universal acceptation.

W. H. G.

PHILLIPS'S "MANUAL OF GEOLOGY"

Manual of Geology, Theoretical and Practical. By John Phillips, LL.D., F.R.S. Edited by R. Etheridge, F.R S., and H. G. Seeley, F.R.S. Pp. 546. (London: Chas. Griffin and Co., 1885.)

THERE are two ends which a Manual of Geology, or for the matter of that of any science, may be intended to compass. It may be meant for beginners, or it may be designed for the use of advanced students. And the ways in which the subject must be handled in order to meet the needs of the two classes are essentially distinct; for it is no less true in intellectual than in physical development that the infant and the adult require different modes of treatment and different kinds of nourishment.

At the very opening of the work before us we find, on a fly-leaf by itself, evidently placed in a conspicuous position for the purpose of calling special attention to it, the aphorism, "Knowledge should be practical from the first," and directions follow as to the way in which the reader can best obtain the specimens by the aid of which alone his knowledge can be rendered practical. Such instructions would be superfluous in the case of advanced students, and we must conclude that the book is intended for beginners. We are warned in the preface that "of things good and beautiful the gods give nothing to men without great toil"; this is a truth which the real teacher never fails to impress on those whom he aspires to guide along the rugged roads that lead to the heights of learning, but at the same time he finds his first and best joy in rolling aside as far as he can the obstacles that lie so thick on the path, and, when he cannot clear them away, in helping the novice with tender, loving hand to surmount them, and the wish that lies nearest to his heart is to make the journey as smooth and easy as is compatible with thoroughness. It can scarcely admit of a doubt that the way to do this is to begin with the simple, the known, and the certain, and gradually lead on to the complicated, the doubtful, and the hypothetical. And it is not only because it smooths the beginner's path that this is the more excellent way, it is even more than that, because it engenders from the outset a habit of clearly distinguishing between what we may fairly look upon as established truths and the things which are still matter of speculation. If hypotheses are forced on the student's attention in the early part of his career, and still more if these hypotheses are spoken of as if they were universally-accepted doctrines, the learner soon ceases to distinguish between fact and theory, and his scientific studies lead only to confusion of thought and a habit of jumping to conclusions from imperfect data.

It is for these reasons that I cannot help doubting the wisdom of introducing so early as the second chapter questions about which so very little is known for certain as the composition and condition of the earth's interior, the origin of the earth's figure, and the nebular or meteoric origin of the earth itself. The author is, however, countenanced in this by the practice of many eminent geologists, and I will not therefore press the objection; but I feel little doubt that he has not acted in the best way for the interests of those for whom he seems to have written when, only two chapters further on, he plunges into the vexed question of the origin of the crystalline schists. Chapter IV., which deals with this matter, begins, "The newest water-formed rocks are similar in appearance to deposits which are now being deposited." Not a word has yet been said about the class of rocks described as water-formed, nor any reason given why they are believed to have been formed in water. Why should this be taken for granted when it is a matter so easy to understand and about which there is so little difference of opinion? Surely it would have been safer for a beginner to make the demonstration of a proposition so simple as this his introduction to the study of geology, than to launch him at the outset on a sea of speculation when he is tossed to and fro by conflicting theories and bewildered by the opposite opinions which different authorities hold. Our author, it is true, evades this danger, but he does it in a way that is distinctly unfair to his readers. He shows that it is not impossible that crystalline schists may be produced by the metamorphism of sedimentary deposits, and then lays it down, without any further reason, that *all* rocks of this class have been produced in this way, but he says nothing to lead us to suspect that this is at best an hypothesis, still less that it is an hypothesis which many geologists decline to accept. This looks very much like one of those sweet and easy ways which are so severely denounced in the preface. Nor is his further development of the subject any less unsatisfactory. He gives one of the many reasons that have been alleged in favour of the view that granite is also a product of metamorphism; goes on to the further step that granitic rocks are the deep-seated forms of lavas, and so leads up to the conclusion that all crystalline rocks are metamorphic products. There are many geologists, myself for one, who look favourably on this speculation, who are even sanguine enough to believe that the day will come when it will be placed among established facts, but I could hardly have thought it possible that any scientific writer could have stated it in the present day as a thing about which there was no question; and it scarcely seems prudent, when geology offers us so much that is sure and certain on which to base our teaching, to choose one of the most speculative of its tenets as the foundation for a scheme of instruction.

A chapter follows on the "Nature, Composition, and Origin of the Water-formed Rocks," which illustrates under a typical form the defects and excellences of the greater part of the book. There is much admirable matter and the illustrations are well chosen, but it would be very hard to teach from this chapter. The facts are all strung together in a continuous narrative, somewhat scattered, too, so that if we wished to make out all the steps in the formation of a certain rock, say an organic limestone, we should have to pick out a clause here and a sentence there and piece these fragments together. In fact, this and many other parts of the book remind us of a formation rich in organic remains, but requiring much labour to unravel because the fossils are embedded in rock, are mixed confusedly together, and are, many of them, fragmentary. We do not put a beginner in palæontology to work on such a deposit, but let him first get systematic knowledge in a museum where the fossils have been extracted and set up in order. And it is just such orderly arrangement of the facts and the deductions that follow from them which is wanted in a scientific manual intended for a beginner; they ought not to be embedded in the text, where they have to be hunted for, but they want picking out and placing each by itself in a strong light so that they may catch the eye of the student. Again, if we remember that the materials out of which the water-formed rocks are built up were furnished by denudation, it would seem that an account of the origin of these rocks must necessarily begin with a description of the mode of action and products of denuding agents, but for this we have to wait till we reach Chapter XI. That chapter and Chapter X. furnish one of the most perfect instances of the "cart before the horse" to be met with anywhere. Chapter X. is headed "The General Features of the Scenery in their Relation to Geological Phenomena"; in it, while due weight is given to the influence of upheaval in determining the shape of surface, the large share which denudation has played in forming hill and valley is fully recognised; but it is not till we come to the following chapter that we are told what denudation is and how it works.

The author may say, however, that all this is very much matter of opinion, that I have my notions as to the way in which geology is to be taught and the order in which its subject-matter is to be presented, and that he has his. It may be so, but there are in the book slips and errors about which there can be no difference of opinion, and to which I feel sure the author himself will be glad to have his attention called. We do not generally describe charcoal as uncrystallised diamond, but this would be nearly as bad as "calcite in an uncrystallised condition" (p. 47);

we can hardly agree with the statement that "clay is identical in composition with felspar" (p. 46), when we remember that the one contains about 47 and the other about 65 per cent. of silica; it is somewhat a surprise to find the old time-honoured section of a mountain chain, given in Fig. 34, p. 80, still surviving; if one wished to select a section of what a mountain-chain is not like, here we have it. What would Mr. Huggins say to the statement on p. 17, that "the nebulæ are now known to be in no respect nebulous"? On p. 22 we are told that, "when a typical felspar contains potash, it is recognised by fracturing at right angles to the side (*sic*) of the prism." This is hardly calculated to convey a notion that potash felspar has two cleavages, and certainly gives no definite idea of the direction of either.

The treatment of the subject of joints is bewildering; it reminds me of the advice given to a youthful and diffident teacher, "If you are asked to explain any thing you don't understand, look solemn and talk of polar forces." We have vague hints that the crystallisation of monoclinic augite and triclinic plagioclase may in some mysterious and unexplained way have determined the direction of the cracks on the hexagonal jointing of basalt, and that the structure is essentially crystalline (p. 43); then, on p. 82, our mind is unsettled by the statement that tension in successively different directions is more probably the true cause of the phenomena of jointing in slaty rocks; then heat and electricity, it is surmised, may have had something to do with it. Surely in the place of these guesses, or at least in addition to them, it would have been well to mention some of the facts that throw light on the solution of the problem; that the columnar structure of basalt is closely mimicked by the hexagonal columns of starch and dried clay in the formation of which crystallisation took no share; and that Daubrée has produced, by torsional strain, cracks, the directions of which follow the same law as governs the trend of master-joints in rocks. It is this preference of shadowy surmise to solid substantial fact which constitutes one main fault of the book. The notice of "reversed faults" on p. 77 is incomplete; Rogers and Heim have taught us that these are the rule in violently contorted districts, and the latter has given a beautiful explanation of how they have been produced. The formation of coal is dismissed in ten lines, at least this is the only reference to coal given in the index, and I have not found anything on the subject elsewhere in the book. When I think what an admirable instance of inductive reasoning the discovery of the terrestrial origin of coal supplies, and how the study of sound inferences like this is one of the best ways of developing the logical faculty in the student, I cannot help regretting that some of the questionable speculations with which the book abounds have not been left out to make room for an account of the way in which this truth was arrived at. I fear very much that the directions given on p. 253 will not help the student much to identify minerals under the microscope. One would gather from them that colour was the one important point to attend to, for this is almost the only thing noticed; and it is strange that in the case of olivine, where the extreme vividness of the colours is of some little use as a distinctive test, no notice is taken of the fact. Amphibole, it would seem, is to be distinguished from pyroxene by giving brighter colours, but the widely different cleavages of the two minerals, and the dichroism of the one and its absence in the other are passed over. Nor is a word said about the dichroism of tourmaline and magnesian mica. Of the many points to be attended to only one is mentioned, and the most important facts under that head are omitted.

For such reasons as I have given I cannot help feeling that this work is unsuited for teaching purposes; indeed, on account of the way in which it mixes up theory and fact, I should say it would be positively dangerous to put it into the hands of a beginner.

But it will be by no means without its use to those who have made some progress in the study of geology. It is an admirable geological gazetteer. The long lists of localities where typical examples of the various classes of rocks may be studied and the condensed descriptions of the geological structure and history of the various districts cited, will be of great value. References to original memoirs are frequently given, but they might be largely increased with great advantage; it would be scarcely possible to make them too numerous. There is much, too, in the speculative portion of the book, which, even if it be in places hazy and but slightly supported either by observation or experiment, is still very acceptable. Even the guesses of an acute and original thinker are welcome.

In the section devoted to palæontology the puzzles and uncertainties of that branch of geology are stated without reserve, and the lines on which the palæontologist must work are clearly marked out. The chapter on the "Succession of Life in Classes and Orders of Animals" is too crowded with detail for beginners, but I fancy that the advanced student will often turn to it for reference and thank the author for having furnished him with such a concise index to the subject. The brief indications given under each head will serve as starting points, and as he develops and expands his knowledge by the aid of special treatises and original memoirs, the student will find out for himself where the author is propounding his own peculiar views, and where he is in accord with his fellow-palæontologists.

A. H. GREEN

OUR BOOK SHELF

Transit Tables for 1885. By Latimer Clark, M.I.C.E., &c. (London: E. and F. N. Spon, 1885.)

At a period when the question of universal time is in every one's thoughts, more or less, these tables should possess more than ordinary interest. By the production of a simple, efficient, and inexpensive transit instrument Mr. Clark first demonstrated that transit observations were within the power of others than the professional astronomer or the wealthy amateur, and that by these observations timekeepers could be regulated to the fraction of a second. The next step was to simplify the calculations involved in the reduction of these observations, by the yearly publication of tables giving in Greenwich mean time, instead of sidereal time, the transits of the sun and a few of the principal stars conveniently situated for observations for every day in the year. This is chiefly what is accomplished in these tables, now in their fourth year of publication. In addition to the fundamental stars, the transits of five of which are given for every